Environmental and Biological Heterogeneity in the Northeastern Chukchi Sea

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Background

Distributions of benthic organisms are coupled with environmental parameters suitable for each organism. Additionally, some organisms are adept at modifying their surroundings to create new micro-scale environments. The sum of these interactions results in uneven distributions of physical habitat characteristics and biological communities. Often described as "oceanographically smooth", the northeastern Chukchi Sea is better depicted as a mosaic of benthic habitats and communities painted by large scale oceanographic processes, and highlighted by smaller scale topographic features.

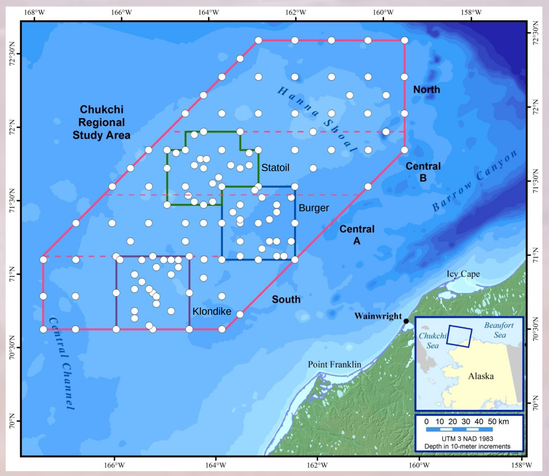


Fig. 1: CSESP study area, 2008-2012.

Data and observations collected in 2008-2012 as part of the interdisciplinary Chukchi Sea Environmental Studies Program (CSESP) demonstrate the environmental and biological heterogeneity of the area. Five years of sampling were conducted in Klondike and Burger, three years in Statoil, and two years in the Regional Study Area (Fig 1).

Benthic sampling was carried out using van Veen grabs for sediment dwelling organisms (infauna) and bottom trawls or video surveys for organisms living on or near the sediment surface (epifauna).

Environmental Heterogeneity

Water circulation across the study area is complex (Fig. 2). The South and North strata have predominantly flow-thru circulation, while the Central strata have areas of opposing or convergent flow. Topographic features reflected by water depth (Fig. 3, top panel) direct water flow.

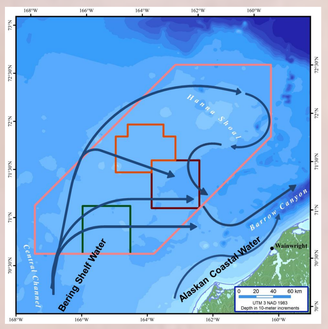


Fig. 2: Proposed circulation pattern in the northeastern Chukchi Sea (after Spall 2007; Weingartner et al 2005, 2013)

Other environmental characteristics varied throughout the regional study area and were likely driven by water circulation patterns (Fig. 3).

A gradient of bottom water temperature is established as warmer Bering Shelf Water moves northward, seasonally displacing cold winter water.

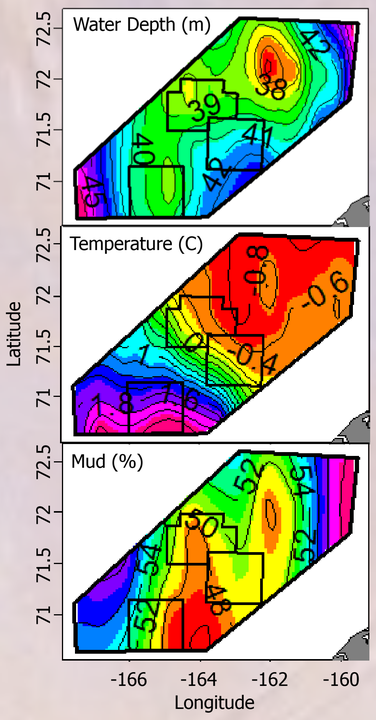


Fig. 3: Geospatial models of environmental variables, 2011-2012 CSESP surveys.

The mud (fine particle) fraction of the sediment increased near areas where water flow slowed (e.g. convergence zones).

Sediment composition varied between strata (Fig. 4). The South stratum had the lowest mud fraction and the highest fraction of gravel. Rocky patches observed during video surveys were poorly represented. Central A had the highest proportion of mud, reflecting the water flow convergence zone occurring in the eastern half of the stratum. Central B and North had intermediate characteristics.

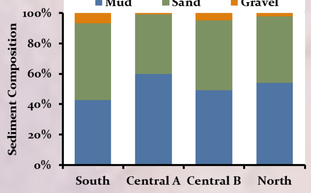


Fig. 4: Sediment grain size characteristics, 2011-2012 CSESP surveys.

References

Spall. 2007. Journal of Geophysical Research 112:C05025.

Weingartner et al. 2005. Deep Sea Research Part II 52:3150-3174.

Weingartner et al. 2013. Continental Shelf Research 67:5-22.

Biological Heterogeneity

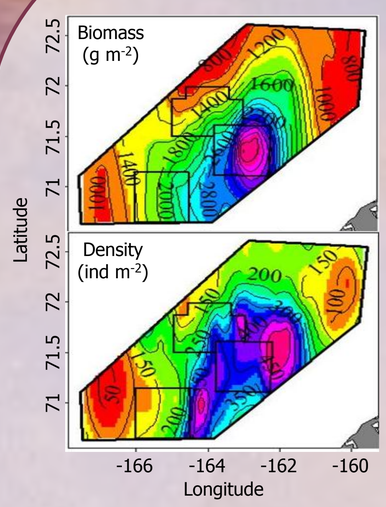


Fig. 5: Geospatial models of infaunal community characteristics, 2011-2012 CSESP surveys.

Benthic communities were not equally distributed across the regional study area. Areas of high biomass and density were observed adjacent to Burger (Fig. 5). Peaks corresponded with sediment characteristics, although patterns were not as strong as expected.

Species richness decreased from south to north overall (Table 1). Infauna and epifauna followed this pattern.

Table 1: Benthic community richness, 2008-2012 CSESP. Data are from van Veen sampling only.

	South	Central A	Central B	North
Infauna	364	324	308	201
Epifauna	56	39	31	21
Overall	420	363	339	222

From an ecological perspective, benthic community composition between strata was similar when standardized by biomass or density (Fig. 6). Differences between communities were at the species level.

For example: suspension feeders

South → organisms primarily upright attached to rocks (sea squirts, bryozoans) or buried (clams)

Central A/B → organisms primarily at or near sediment surface (clams)

North → organisms primarily at or near sediment surface (bryozoans, sabellid worms, clams)

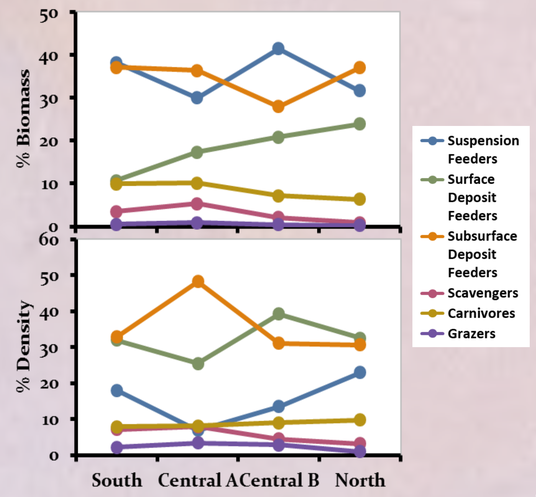


Fig. 6: Benthic community composition by functional groups by biomass and density, 2008-2012 CSESP surveys. Data are from van Veen sampling only.

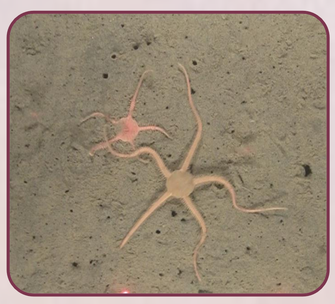
Conclusions

- Habitat, and consequently benthic community structure, demonstrates significant heterogeneity on large and small spatial scales in the northeastern Chukchi Sea.

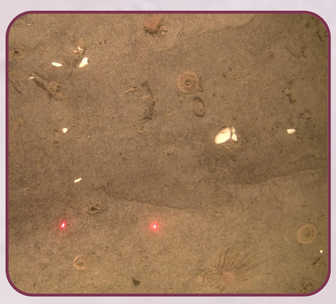
South
- Flow-thru water circulation
- Warmest
- Muddy with rocky patches
- Upright and buried suspension feeders
- Highest species richness

Central A
- Convergence areas
- Predominantly muddy
- Buried suspension feeders
- Moderate species richness
- High biomass and density

Central B
- Convergence areas
- Mixed sediment
- Buried suspension feeders
- Decreased species richness
- High density, moderate biomass



North
- Flow-thru water circulation
- Coldest
- Mixed sediment
- Surface and buried suspension feeders
- Lowest species richness
- Low biomass and density



- While environmental heterogeneities seem small in magnitude, they have significant ecological effects on the density, biomass, and composition of benthic communities.

Acknowledgments

We thank ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc., for funding this study. Olgoonik Fairweather LLC, the crews of the *M/V Bluefin* (2008) and *M/V Westward Wind* (2009-2012), Aldrich Offshore Services and Olgoonik Oilfield Services provided logistics and support. Many field and lab technicians helped with sample collection and processing.

Ocean Sciences Meeting **23-28 February 2014** **Honolulu, Hawai'i**